

REMARKS

Claims 1-25 are pending in the present Application. Applicant amended claims 1, 20, 21, and 23 and added new claims 24 and 25. All amendments are supported by the specification.

Claim Rejections - 35 USC § 102

The Examiner rejected Claims 1-3, 5-9, 11-23 under 35 U.S.C. 102(b) as being anticipated by Lauw (US 5,559,685). The Examiner states:

Claims 1, 20, 21 and 23; Lauw et al, figure 4, disclose a converter circuit, comprising: an AC-to-DC converter (20), comprising a plurality of first power devices (21-23); a resonant DC link (30), comprising at least one auxiliary power device (S_{C1}, S_{C2}); a DC-to-AC converter (10), comprising a plurality of second power devices (BH₁-BH₃, BL₁-BL₃); and DC link lines (32, 35), coupling the AC-to-DC converter, the resonant link, and the DC-to-AC converter, wherein the auxiliary power device (S_{C1}, S_{C2}) is coupled between the DC link lines.

Claims 14-16; Divan discloses a resonant capacitor (C_C or C_S or C_R); a diode (D_C); and a switch (S_{C1}, S_{C2}); coupled between the DC link lines and parallel with each other.

Claims 17 and 22; figure 3 – (S_{C2}).

Claims 18 and 19; first capacitor (C_C), auxiliary power device (S_{C1}, S_{C2}), resonant capacitor (C_R), inductance (L_R), second capacitor (C_S).

In response, Applicant respectfully points out that Lauw does not recite several claim elements and therefore does not anticipate independent Claims 1, 20, 21, and 23.

1. Lauw does not recite: “a converter circuit having only one auxiliary power device”. Visibly, Lauw has two power devices S_{C1} and S_{C2}.

Implementing an additional power device in the DC link line of the converter considerably increases the power loss and thus reduces the efficiency. It also requires the introduction of an additional power controller device. In particular, an additional gate driver is required. Since the additional power device is in the high voltage DC link line, the gate driver has to be isolated from the ground. Also, an additional timing control signal has to be generated as well. Because of all these requirements, implementing a second power device

introduces considerable complexity, increases the price and reduces the efficiency of the circuit. Therefore, a converter circuit with only one auxiliary power device is qualitatively better than converters with two power devices. Because of this distinctive difference, independent Claims 1, 20, 21, and 23 are patentable over Lauw.

2. Lauw does not recite a converter, where “a first terminal of the auxiliary power device is connected to the first DC link line and a second terminal of the auxiliary power device is connected to the second DC link line”. Visibly, power devices S₁ and S₂ are in the main DC link lines, instead of between them.

As Applicant explained both in the application itself and in the Response to the First Office Action, moving the power device from being in the DC link lines to being between the DC link lines in the claimed manner brings about crucial improvements.

To appreciate this point more clearly, Applicant refers to the timing diagram of FIG.

4. In FIG. 4, the current $i_{Qr}(t)$ represents the current through the auxiliary power device.

Current $i_{Qr}(t)$ is essentially zero over most of the operating cycle of the converter.

Quantitatively, in embodiments the current $i_{Qr}(t)$ is non-zero for less than 10% of the operating cycle, as can be appreciated from comparing the duration of the current spike between t_0 and t_1 , and the length of the entire operating cycle between t_0 and t_7 . In some embodiments this ratio is less than 2%. Therefore, power devices, which are coupled between the DC link lines, have a current flowing through them only a few percent of the operating cycle. In contrast, the current in the main DC link is a steady, DC current. Thus, power devices coupled into the DC links have a current flowing through them essentially the entire operating cycle. This clearly demonstrates that converters with power devices coupled between the DC links reduce the power loss 10-50 times ($=100/10$ to $100/2$, the ratio of the on-times of the two types of converters). This is very clearly a critical difference between the two types of converters. Because of this distinctive and critical difference, independent Claims 1, 20, 21, and 23 are patentable over Lauw.

This difference between the on-times is also captured explicitly in newly added claim 24.

3. Lauw does not recite a converter, where “the resonant DC link is operable to clamp an operating voltage of the converter.”

Since Lauw’s power devices are not connected to the ground, they are unable to clamp the operating voltage of the converter. As described in the Response to the First Office Action, the operating voltage can have spikes reaching 800-1000 Volts in unclamped converters like Lauw’s. This value represents a 2-3 fold increase over the regular operating voltage. In contrast, embodiments of the present invention clamp the voltage close to the operating voltage, around 300-400 Volts. It is evident that losses during the spikes are much higher in unclamped converters than in clamped converters. Further, power devices with much higher voltage ratings have to be used in unclamped converters, making their manufacture more expensive and eventual price higher. Because of these distinctive and critical differences, independent Claims 1, 20, 21, and 23 are patentable over Lauw.

In sum, Lauw does not recite at least three elements of independent Claims 1, 20, 21, and 23 and therefore does not anticipate independent Claims 1, 20, 21, and 23. Furthermore, Applicant demonstrated that embodiments of the present invention offer critical improvements over Lauw, including a factor of 10-50 improvement in efficiency, a factor of 2-3 reduction in voltage ratings of the power device, and a profound reduction in circuit complexity and price. At least for all these reasons, independent Claims 1, 20, 21, and 23 are patentable over Lauw.

Dependent Claims 14-19 and 22 depend from allowable independent Claims 1 and 21, and are therefore themselves allowable.

Applicant notes that the reference to Divan in relation to Claims 14-16 was probably misplaced. Judging from the labels and explanations, which are present in Lauw but not in Divan, furthermore that Divan is listed as a reference not relied upon, Applicant respectfully assumes that the reference to Divan was misplaced and therefore did not respond to those points of rejection in the Office Action.

The Examiner rejected claims 4 and 10 under 35 U.S.C. 102(b) as being anticipated by Lauw et al. (US 5,559,685) in view of Lee et al. (US 5,633,793).

Claims 4 and 10; Lauw et al discloses the claimed subject matter in regards to claims 3 and 9 supra except for the power transistors comprises a first power diode being coupled between a source and a drain of a MOSFET first power transistor.

Lee et al teaches that each bridge switch of a converter and rectifiers has an anti-parallel diode associated therewith; and it is understood that these anti-parallel diodes may be either discrete components or the body diode in the case of an active switch such as a MOSFET.

Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Lauw et al to incorporate power diodes coupled between a source and a drain of a MOSFET in order to utilize the current carrying characteristics of MOSFETs as switching devices and as suggested by Lee et al.

Claim 4 depends from independent Claim 1, which has been shown to be allowable. Therefore, Claim 4 is allowable as well.

Furthermore, Applicant respectfully points out that combining Lauw with Lee does not result in a 35 U.S.C. §102 rejection. At best, it results in a U.S.C. §103, obviousness type rejection. However, the Examiner did not provide any explicit motivation to combine these two references, whereas any obviousness type rejection must contain such an explicit motivation, as stated by the Federal Circuit and the MPEP. Without a clear motivation to combine, the Lauw and Lee references do not result in a proper 103 rejection.

Moreover, Lauw, even in combination with Lee, does not recite the following claim elements and therefore does not make Claim 1, and its dependent claim, Claim 4 obvious.

In FIG. 6, Lee describes three switching/power devices in a block, which are related to the resonant DC link: D, Daux and Saux. In contrast, Claim 1 recites “a resonant DC link, comprising only one auxiliary power device”. Therefore, Lauw, in combination with Lee, does not anticipate this claim element.

To further emphasize this point, Applicant added new claim 25, which recites:

“25. (New) The converter circuit of claim 1, wherein
the resonant DC link does not have switching devices.”

Also, given that the polarity of Saux is opposite of auxiliary power diode 124 in FIG. 1 of the present application, even if Lee is combined with Lauw, the resulting converter is unable to clamp the operating voltage. In contrast, Claim 1 recites: “the resonant DC link is operable to clamp an operating voltage of the converter.” Therefore, Lauw, in combination with Lee, does not anticipate this claim element.

The Examiner also notes that

“Lee et al teaches that each bridge switch of a converter and rectifiers has an anti-parallel diode associated therewith; and it is understood that these anti-parallel diodes may be either discrete components or the body diode in the case of an active switch such as a MOSFET.”

In response, Applicant respectfully notes that Lauw itself already describes anti-parallel diodes existing across the switching devices Sc1 and Sc2. The Examiner is correct, it is widely understood that these diodes can be explicit or implicit body diodes. Therefore, combining Lauw with Lee in the manner described by the Examiner does not introduce any new ground of rejection.

Finally, Applicant notes that Lee describes having a switching device D in the main DC link, once again disadvantageously leading to large power losses.

In summary, combining Lauw with Lee in the manner described by the Examiner lacks motivation. Further, this combination neither recites several claim elements, nor makes them obvious. For all these reasons independent Claim 1 and its dependent claim, Claim 4 is allowable over Lauw, even in combination with Lee.

CONCLUSION

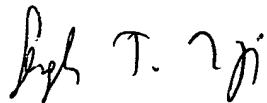
In light of the above remarks and with the above amendments, Applicant respectfully submits that all pending claims are in condition of allowance and therefore their allowance is requested. If any of the claims require further clarification or discussion, the undersigned is readily available at (415) 772-1200.

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